

# ***AN-2006 Synchronizing a DP83640 PTP Master to a GPS Receiver***

---

## **ABSTRACT**

This application report discusses methods of synchronizing the precision time protocol (PTP) clock to a GPS receiver using the DP83640 precision PHYTER™.

---

## **Contents**

1	Introduction .....	2
2	Synchronization Methods .....	2
2.1	Pulse-Per-Second Synchronization .....	2
2.2	Direct Reference Connection .....	3
3	Summary .....	4
4	References .....	4

## **List of Figures**

1	Block Diagram Using 25 MHz Reference not Connected to the GPS Source.....	3
2	Block Diagram Using 25 MHz Reference Connected to the GPS Source .....	4

## 1 Introduction

The IEEE 1588 precision time protocol provides a means of synchronizing the time between multiple nodes using standard Ethernet connections. In many applications, telecommunications in particular, synchronization of the local time base is essential to system performance. In these applications, a GPS receiver is typically used to synchronize remote sites. This method, however, is expensive due to the cost of the providing a GPS receiver at each remote site. An alternate method is to utilize a single GPS receiver as the time base for an IEEE 1588 Master and synchronize the remote sites using the Ethernet and the IEEE 1588 precision time protocol.

## 2 Synchronization Methods

Synchronization can be accomplished using a DP83640 clock reference that is independent of the GPS receiver clock or that is dependent upon the GPS receiver clock source. The DP83640 reference clock for the pulse-per-second synchronization described in [Section 2.1](#) is independent of the GPS receiver. The direct reference connection simplifies the control loop by taking advantage of the GPS receiver output clock.

### 2.1 Pulse-Per-Second Synchronization

The pulse-per-second synchronization method, shown in [Figure 1](#), assumes that the GPS receiver is operating as a valid time reference.

A general outline of the steps required to synchronize the PTP clock to the GPS clock is as follows:

1. Initialize the PTP clock in the DP83640.
2. Configure a general-purpose input/output (GPIO) as an event monitor to detect the rising edge of the PPS output from the GPS receiver.
3. Upon detection of the first PPS event,
  - (a) Capture the timestamp of the event.
  - (b) Read the time from the GPS unit.
  - (c) Calculate the difference between the GPS time and the PTP time and use a step adjustment to correct the PTP time.
4. Since the PPS output of the GPS receiver will occur at 1-second intervals, it should not be necessary to poll the GPS receiver for the time with each captured timestamp. However, to ensure continued accuracy of the system, the GPS and PTP times should be checked and verified periodically.

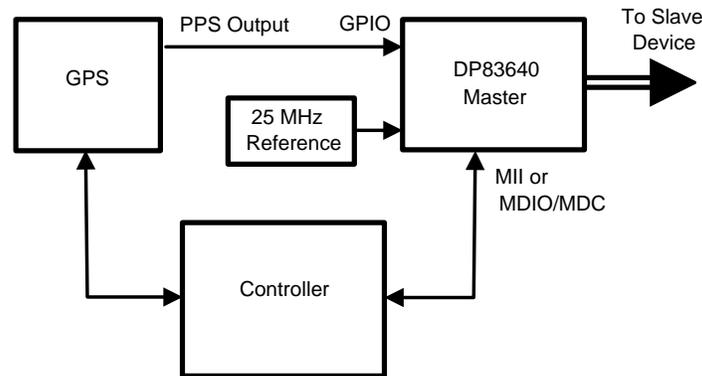
---

**NOTE:** The initial PPS event captured will most likely result in a large (> 1 second) delta between the GPS time and the local time of the DP83640. After the initial time adjustment, subsequent timestamps should be within a 1 second error and allow for temporary rate adjustments to further adjust the time of the PTP clock.

---

With this configuration, the 25 MHz reference used for the DP83640 will not track the reference of the GPS source exactly. As a result, the PTP clock will require rate corrections to compensate for differences in the reference clock rates. The rate correction can be calculated based on the difference in time stamps between sequential PPS edges.

In the case where the 25 MHz reference to the DP83640 is a voltage-controlled oscillator, it is possible to adjust the oscillator frequency based on the needed rate correction as an alternative to performing the rate correction to the PTP clock. In this instance, care should be taken in selecting a D/A converter that will provide sufficient voltage resolution to meet the system clock accuracy requirements.



**Figure 1. Block Diagram Using 25 MHz Reference not Connected to the GPS Source**

## 2.2 Direct Reference Connection

The direct reference connection method, shown in [Figure 2](#), assumes that the GPS receiver is operating as a valid time reference.

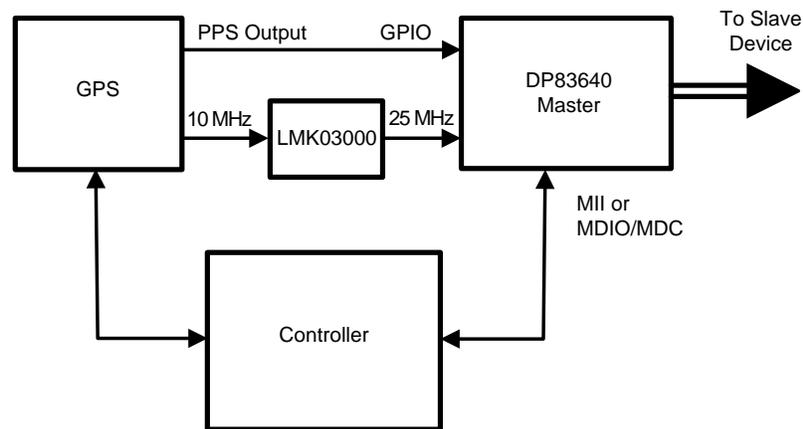
Initialization of the DP83640 PTP clock for the direct reference connection is the same as for the pulse-per-second synchronization. However, with the GPS 10 MHz time-base output used as the basis for the 25 MHz reference to the DP83640, the need to continually perform rate adjustments to the PTP clock is eliminated. To minimize reference clock jitter, the Texas Instruments LMK03000 device is recommended.

1. Initialize the PTP clock in the DP83640.
2. Configure a GPIO as an event monitor to detect the rising edge of the PPS output from the GPS receiver.
3. Upon detection of the first PPS event,
  - (a) Capture the timestamp of the event.
  - (b) Read the time from the GPS unit.
  - (c) Calculate the difference between the GPS time and the PTP time and use a step adjustment.
4. Since the 25 MHz reference to the DP83640 is based on the 10 MHz output from the GPS source, there should be no drift of the PTP clock relative to the GPS clock reference. As such, there is no need to adjust the PTP clock using temporary rate adjustments.
5. With this configuration, there are still benefits to checking the PPS timestamps for accuracy. Since the resolution of the event timestamps is 8 ns, an improvement to the accuracy of the timing could be achieved by averaging sequential timestamps. Periodically checking the PTP clock against the GPS source can also guard against the possibility of a discontinuity in time from the Master.

---

**NOTE:** The initial PPS event captured will most likely result in a large (> 1 second) delta between the GPS time and the local time of the DP83640. After the initial time adjustment, subsequent timestamps should be within a 1 second error and no further adjustments to the time of the PTP clock should be required.

---



**Figure 2. Block Diagram Using 25 MHz Reference Connected to the GPS Source**

### 3 Summary

This application report presented two methods of synchronizing the IEEE 1588 PTP clock to a GPS clock source. Both methods provide an efficient means of synchronizing remote sites without the additional cost of a GPS receiver at each site. The pulse per second method achieves synchronization using a minimized hardware configuration supported by rate correction. The direct reference connection method achieves synchronization without the need for continuous rate correction through the addition of an LMK03000 device. Although both of the methods described above allow the PTP clock to be synchronized to the GPS clock, the direct reference connection method also allows the PHY to be a master for synchronous Ethernet operation with the transmit clock frequency being the same as the IEEE 1588 reference clock frequency.

For additional information related to the programming and synchronization of the DP83640, see [Section 4](#).

### 4 References

- *DP83640 Precision PHYTER - IEEE 1588 Precision Time Protocol Transceiver Data Sheet* ([SNOSAY8](#))
- *AN-1728 IEEE 1588 Precision Time Protocol Time Synchronization Performance* ([SNLA098](#))
- *AN-1729 DP83640 IEEE 1588 PTP Synchronized Clock Output* ([SNLA099](#))
- *AN-1730 DP83640 Synchronous Ethernet Mode: Achieving Sub-Nanosecond Accuracy in PTP Applications* ([SNLA100](#))
- *Texas Instruments Ethernet PHYTER - Software Development Guide.*

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

### Products

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

### Applications

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

### TI E2E Community

[e2e.ti.com](http://e2e.ti.com)